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Authors
Kang Sim, D Eastern
Strong, David R
Manzano, Michael
et al.

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Evaluating Psychometric Properties of the Emotional Eating Scale Adapted for Children and Adolescents (EES-C) in a Clinical Sample of Children Seeking Treatment for Obesity: A Case for the Unidimensional Model

(Contributors; orders can be rearranged)

D. Eastern Kang Sim[a]

David R. Strong[b]

Michael Manzano[a]

Dawn M. Eichen[a]

Kyung E. Rhee[a]

Marian Tanofsky-Kraff[c]

Kerri N. Boutelle[a,b,d]

[a] Department of Pediatrics, UC San Diego,9500 Gilman Drive, MC 0874, La Jolla CA 92093, USA (dkangsim@ucsd.edu; m3manzano@ucsd.edu; deichen@ucsd.edu; k1rhee@ucsd.edu; kboutlle@ucsd.edu)

[b] Department of Family Medicine and Public Health, UC San Diego, 9500 Gilman Drive, La Jolla CA 92093-0725, USA (dstrong@ucsd.edu; kboutelle@ucsd.edu)

[c] Department of Medical and Clinical Psychology, Uniformed Services University, 4301 Jones Bridge Road, Bethesda MD 20814, USA (marian-tanofsky-kraff@usuhs.edu)

[d] Department of Psychiatry, UC San Diego, 9500 Gilman Drive, MC 0874, La Jolla CA 92093, USA (kboutelle@ucsd.edu)

Correspondence concerning this article should be addressed to D. Eastern Kang Sim, the CHEAR, UC San Diego, 9500 Gilman Drive, La Jolla, CA 92093. E-mail: dkangsim@ucsd.edu

Abstract:

Background: The Emotional Eating Scale adapted for children and adolescents (EES-C) assesses food-seeking behavior and overeating in response to a range of mood or affects. Despite the fact that prior psychometric studies have demonstrated high reliability, concurrent validity, and test-retest reliability of theoretically defined subconstructs, no prior studies of the EES-C have focused on a clinical sample of children with overweight or obesity. The purpose of this study was to assess construct validity of a single-construct and a proposed scoring of two sub-constructs.

Method: Using a hierarchical bi-factor approach, we evaluated the EES-C's validity in assessing a single general construct, a set of two separate correlated subconstructs, or hierarchical arrangement of two constructs, and determine reliability in a clinical sample of treatment-seeking overweight or obese children aged 8 to 12.9 years (N=150).

Results: The present study demonstrated that rigorous factor-extraction methods suggest a one-factor solution. The bi-factor indices provided clear evidence that most of the reliable variance in the total score (90.8 for bi-factor model with three grouping factors and 95.2 for bi-factor model with five grouping factors) was attributed to the general construct. Correlated subconstructs that are currently identified in the clinical sample were unreliable after the variance explained by the single general construct.

Conclusion: Results suggest that the primary interpretive emphasis of the EES-C among treatment-seeking children with overweight or obesity should be placed on a single general construct, not at the subscale level.

Keywords: emotional eating; scale development

Introduction

The Emotional Eating Scale (EES) for adults was designed to assess food-seeking behavior and overeating in relation to a range of moods or affects [1]. The EES was adapted for use with children and adolescents to determine whether similar behaviors occur at this younger age [2]. Prior psychometric research on the Emotional Eating Scale Adapted for Children and Adolescents (EES-C) has shown strong internal consistency reliability, concurrent validity with general indices of disordered eating and general emotional problems, and test-retest reliability of theoretically defined constructs on separate subscales [2-5]. Although theoretically defined subscales of the EES-C have been useful tools to investigate the relationship between various affectivity and overeating in children [1, 2], there are discrepancies in the proposed number of subscales for children depending on the context in which it is used [2, 4, 5]. For instance, the original validation study by Tanofsky-Kraff [2] proposed three subscales ('Anger, anxiety, frustration', 'depression', and 'unsettledness'). Using the Spanish version of the EES-C, Perpina et al. [5] suggested five subscales ('anger', 'anxiety', 'depression', 'restlessness', and 'helplessness'). It is not surprising, thus, that Vannucci and colleagues found that a total score (the sum of all items, other than eating in response to feeling "happy") showed construct validity with negative mood and energy intake [3].

However, in a clinical setting, the differentiation of subscales may not be apparent among children with overweight or obesity who are likely to generate high levels of emotional eating across all domains [6, 7]. As children participating in the previous studies were predominantly healthy weight, with only one-third of children having overweight or obesity, it will be valuable to evaluate the psychometrics of the

EES-C and its true dimensionality between a single-construct and a sub-constructs in a clinical sample [2].

To the best of our knowledge, no prior psychometric study of the EES-C has assessed a mix of single and subscale evaluations. The hierarchical bi-factor model, which concurrently describes the common traits such as emotional eating scale and the set of subscales (e.g., eating in response to anger, depression, etc.) may supplement empirical evidence that prior psychometrics studies were unable to contribute [8-11]. By adopting a higher-order factor analysis, we can begin to partition whether responses to items were more likely to arise from smaller correlated subconstructs or if item responses were reflective of a single general dimension. Thus, this study aims to evaluate the validity of the EES-C in a clinical sample of children seeking treatment for overweight or obesity by assessing a single general construct, a set of two separate sub-constructs, or a hierarchical arrangement of the two using a bi-factor approach.

Materials and methods:

The Family, Responsibility, Education, Support and Health (FRESH) study was a randomized clinical non-inferiority trial, conducted between July 2011 and July 2015 in San Diego, California (Clinical Trial: NCT01197443), and evaluated two 6-month treatments for childhood obesity. Detailed recruitment methods are described elsewhere [12, 13]. Briefly, eligibility criteria included children aged 8 to 12.9 years, child body mass index (kg/m^2, BMI) from 85th to 99.9th percentile, a parent in the household with a BMI of at least 25 kg/m^2, and availability to participate in the study on designated evenings. Children with medical or psychiatric conditions that could interfere with participation in the treatment were excluded. In total, 150 children who meet the inclusion criteria and their parents were recruited through local advertisement, school listservs, and local pediatric clinics. The current study uses measures completed by these children at baseline, prior to starting any treatment. The institutional review boards of the University of California San Diego and Rady Children’s Hospital, San Diego, California approved the study. Written consent and assent were obtained from parents and children, respectively.

Emotional Eating Scale Adapted to Use in Children and Adolescents (EES-C): The EES-C is a 25-item questionnaire that assesses eating when confronted with 25 negative emotions (e.g., resentful, discouraged, etc.) on a 5-point Likert scale (from “no desire” to “very strong desire to eat”) [2]. Summing the individual EES-C items generates an EES-C total score. To test the convergent and discriminant validity of the scale, we used the median score of the EES-C total score and dichotomized the results into two groups: high in emotional eating (High-EE) and low in emotional eating (Low-EE).

Alternative factor models derived from prior studies [2, 5] in non-clinical samples have been replicated to provide context and described in the analysis section.

Child Eating Disorder Examination (ChEDE): The ChEDE is a semi-structured interview that assesses eating disorder features in children [14]. The overeating section was administered to evaluate the number of objective bulimic episodes (i.e., objectively large amount of food with loss of control over eating) or subjective bulimic episodes (i.e., smaller amount of food but viewed as excess to participant with loss of control over eating) in the past 3 months. To test the convergent validity, we dichotomized children into two groups, 'any experience of loss of control eating' or 'no experience of loss of control eating' respectively [15].

Child Behavior Checklist (CBCL): The CBCL is a parent-report questionnaire that assesses children's behavioral problems [16]. The CBCL yields standardized T scores and age-adjusted scores on internalizing, externalizing, and total behavioral difficulties, which were used to test the discriminant validity of the EES-C. The CBCL has been evaluated in clinical and community populations with good inter-rater and intra-rater reliability [17].

Statistical analysis

All analyses were conducted using the R statistical programing language (version 3.4) [18] and SPSS (version 23, IBM) [19]. Polychoric correlations were used where appropriate [20]. Prior to the bi-factor analysis, we replicated the methods used in prior studies to help define multiple EES sub-constructs for the clinical sample. In brief, these methods used Kaiser-one for class enumeration and principal component or exploratory factor analysis with varimax rotation. We found lack of agreement of exploratory models (e.g. ‘excited/uneasy/resentful’, ‘loneliness’, ‘depression’ for the three-factor model; ‘anxiety’, ‘agitated’, ‘guilty’, ‘upset’, and ‘loneliness’ for the five-factor model), which in turn suggests need to examine in clinical samples. For the current study, we focus on the hierarchical bifactor model which simultaneously evaluate a mix of single construct and subscales. *Construct validity*

The optimal solution for the number of factors to be retained was determined by the Kaiser-one criterion [21]. The following procedures were also tested: 1) Velicer’s minimum average partial (MAP) criteria [22]; 2) Horn’s parallel analysis (PA) [23]; 3) the optimal coordinates (OC) [24]; 4) the acceleration factor (AF) [24]; 5) the Very Simple Structure (VSS) [25]; and 6) Ruscio and Roche’s Comparison Data (CD) [20]. Summing the factored items generated the scores for each EES-C subscale.

Convergent and Discriminant Validity

To assess convergent validity, differences between the groups (High-EE and Low-EE) and all variables of interest were measured using a t-test, and p-values < .05 were considered significant. To assess discriminant validity, Spearman’s correlations were used to determine whether the total and subscale scores for the EES-C were significantly related to the corresponding CBCL internalizing, externalizing and total behavior problems.

Bi-factor model indices

Hierarchical bifactor models were examined to simultaneously evaluate the strength of support for a primary single factor underlying the responses and the degree to which additional group factors suggested the multidimensionality of the remaining variability among items after adjustment was made for relationships with the primary construct [8, 11].

Explained common variance (ECV): ECV was used to estimate the degree to which a general construct and correlated subconstructs could be used to explain and organize item responses [8, 9, 26].

Percent of uncontaminated correlations (PUC): PUC, a bifactor-specific index, presents information on the percentage of correlation that is not contaminated by multidimensionality [27].

Reliability coefficients: Cronbach's coefficient alpha (α) was used to estimate the internal scale reliability coefficient [28]. McDonald's coefficient omega (ω) was used to compliment the alpha coefficient, which estimates the proportion of variance in the unit-weighted total score attributable to all sources of common variance [29]. Omega hierarchical (ωH) and Omega hierarchical subscale (ωHS) were used to estimate the variance that is attributable to a single general construct and/or correlated subconstructs [30-32].

Scalability (Coefficient H): Coefficient H was used to evaluate how well a set of items' scalability represented the latent variable [26].

Results

The mean age of child participants was 10.4 years, and 33.3% (n=50) were males. Almost one-third of the subjects were Hispanic. See Table 1 for participant demographics and characteristics.

Convergent and Discriminant Validity of the EES-C

Table 1 presents support for convergent validity and strong relationships between EES-C total scores and levels of self-reported LOC eating behavior. The median for the EES-C total score was 9.5 (range: 0–74). Therefore, children with EES-C scores <9.5 were categorized as low in emotional eating, and those with total scores ≥ 9.5 were categorized as High-EE. Participants with High-EE did not differ on demographic or anthropometric variables, with the exception that Hispanic children were more likely to be classified in the Low-EE group when compared with their peers in the High-EE group. Children in the High-EE group were more likely to endorse LOC eating than the Low-EE group and BMI-z score did not differ between groups (Table 1). Table 2 presents an examination of discriminant validity of the EES-C total and subscale scores. The correlation coefficients between the percentile of internalizing, externalizing, and total behavior problems on the CBCL with the EES-C total score or subscales (formed with either three or five grouping factors) were all small (range = -0.08 to 0.08). No statistically significant differences were noted, suggesting the EES-C reliably assess a construct of emotional eating that was distinct from general emotional or behavior problems.

Exploring Construct Validity

Figure 1 presents scree plot of indices for determining the number of factors to be retained. While the Kaiser-one approach suggested that five factors to be retained, Velicer's MAP criteria provided minimum squared average partial correlations of 0.02 for the first and second steps, suggesting one or two factors. The remaining four methods (three are displayed in figure 1) suggested that one factor be retained.

Applying the Bi-factor Model

Table 3 presents summary results of standardized factor loadings and bi-factor reliability indices of the three-grouping factor. The single general factor loadings ranged from .57 to .79 across all items and most were within the DeVellis's common criteria for an acceptable range [33]. All subscales item-loadings for correlated factors were poor with the exception of emotional eating in response to feeling 'furious' (.79). Across all factor extractions, the single general factor of the bi-factor model accounted for 90% of reliable variance with 10% of the residual variance spread across subscales. After accounting for the variance due to the general factor, the subscales for the correlated factors accounted for a small proportion of the total variance (ωHS = .17, .11, .37). The remaining 3% of the ω total is estimated to be due to random error. With a coefficient H of .94, the general factor presents near perfect construct replicability. None of the indices of the three grouping factors show strong construct replicability.

Table 4 presents summary results of standardized factor loadings and indices of a bi-factor model with five grouping factors. The single general factor loadings remained strong and ranged from .61 to .80 across all items. Within the bi-factor model with subscale for the correlated five grouping factors, item loadings were all less than 0.50 with the exception of the item 'furious' (.81). The single general factor accounted for 95%

of the reliable variance, implying only 5% of the residual variance is distributed to subscales. After accounting for the variance due to the general factor, the subscale grouping factors accounted for a small proportion of the total variance (ωHS = .11, .14, .18, .33, .14). The coefficient H of .95 suggests strong construct replicability of the general factor, whereas none of the indices of the five grouping factors show strong construct reliability. The fourth grouping factor in this model (FFS-F4; table 4) had an H index of .66 which meets the recommended cutoff for favored construct replicability but had only two items ('furious' and 'angry'), suggesting a set of closely related items strongly defined by eating in response to feeling furious.

Discussion

This study evaluated the construct validity and psychometric properties of the EES-C using hierarchical bi-factor approach among children seeking weight-loss treatment. Nearly all of the reliable variance of the EES-C was captured by a single general construct underlying the responses, and multiple bi-factor indices supported the general factor's unidimensionality. Results suggested that the single general factor of emotional eating directly influenced responses on each of the subscales from the correlated factors rather than simply reflecting an accumulation or indirect influence of separately assessed constructs. Scores from the general factor demonstrated good convergent validity with a measure of LOC eating behavior, and good discriminant validity with no evidence of significant relationships with competing measures of general emotional or behavioral problems from the CBCL.

There are several reasons why it may be useful to use a single general construct for emotional eating in children rather than distinguish between several different constructs of emotions related to eating among treatment-seeking children who are overweight or obese. First, children between the ages of 8 and12 years old are still developing the cognitive and emotional awareness needed to distinguish between different affective states that are represented in the EES-C [34]. Second, children in this age range may best relate their eating behaviors to overall levels of arousal (e.g., furious vs. calm) or general valence of affect (e.g., positive vs. negative) rather than discrete emotions (e.g., lonely).

In terms of applied methodology, our study utilized several newer approaches that move the previous psychometric work conducted on the EES-C forward. One of the greatest challenges in factor analysis is choosing the correct number of factors to retain. The traditional Kaiser one approach suggested that five factors exist in the EES-C. Of the six alternative factor extraction methods tested (OC, AF, PA, CD, VSS, and MAP), five suggested that one factor be retained and the sixth (VSS) suggested that one or two factors should be retained. This implies that, while multiple sources of variability in item responses within the EES-C could be scored separately, the identification of items or relative importance of extracted subscales may not be stable or replicable across studies. Rather, a more stable and parsimonious solution may be to organize all items using the single primary construct, a solution supported by multiple indices that suggest the unidimensionality of this scale.

Another stabilizing methodological approach addresses decisions around which test of correlation to use that would best reflect the ordered categorical response process for these items [2, 4, 5]. The EES-C, which uses a five-point Likert scale, has a strong skewedness or kurtosis, and using the Pearson's correlation may produce factors that are based solely on item distribution similarity and can cause items to appear as multidimensional when, in fact, they are not [35]. In the present study, we have implemented the polychoric correlation approach, which leads to more robust estimations of dimensionality than factor analyses using Pearson's.

Furthermore, our study utilized several modern coefficients to evaluate internal consistency. Prior psychometrics studies of the EES-C have extensively used coefficient alpha (α), which demonstrated strong internal consistency; however, high α values from previous studies may be partly attributable to the many redundant items within the scale, which inflate correlations within the group factor. The reliance on α alone has been criticized as an exclusive indicator of scale reliability because it underestimates true reliability and is not sensitive to violations of assumptions of the unidimensional nature of the scale [36, 37]. By implementing a bi-factor approach, we have partitioned single general and correlated group factor variance to better understand the strength of a single primary factor underlying the EES-C. Upon evaluating the percent of total score variance attributable to a single general factor, ωH provided clear evidence that most of the reliable variance in the total score is attributed to the general factor, not to the subscales. We also provided a coefficient H, which is interpreted as a replicability coefficient. Only the general factor passed the threshold of coefficient H (.7); not all subscales met this criterion. The low coefficient H of all the subscales leads one to be suspicious of construct reliability because they are likely to differ from one study to another and in different contexts. The total score, however, had loadings greater than .90, indicating high construct reliability between studies.

One major strength of this study is its use of newer empirical approaches that have been absent from previous validation studies. These methods provide a more robust evaluation of the psychometric properties of the EES-C and a more complete picture of scale performance. Furthermore, this study examined psychometric properties using a population that had never been evaluated: overweight children seeking to lose weight. Several limitations, however, must be considered. As this was a randomized control clinical trial with a population of children seeking to lose weight, self-report bias may have possibly influenced our participants' responses with regards to their emotional eating behaviors. For instance, the median score of the EES-C of our clinical sample was nominally lower (8-12 years; median 9.5) compared to the previous validation study with 151 youths (8-18 years; median 13) [3]. Including only treatment seeking children do not necessarily generalize to other children with overweight/obesity and not to healthy weight children. Future studies should test the reliability of this scale in other populations while using a similar bi-factor approach.

In summary, these results suggest that for a clinical sample of children with overweight or obesity, the EES-C should be implemented with a unidimensional scale and supports the construct validity of the scale in non-treatment seeking children using a total score [3]. Thus, recommendations to use a single total score should be applied to both treatment-seeking and non-treatment seeking children. Future studies are needed to determine whether the single general factor as manifested in the total score is clinically important.

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Competing Interest: The authors declare that they have no conflict of interest.

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Figure 1. Screen plot of indices for the optimal number of factors to be retained

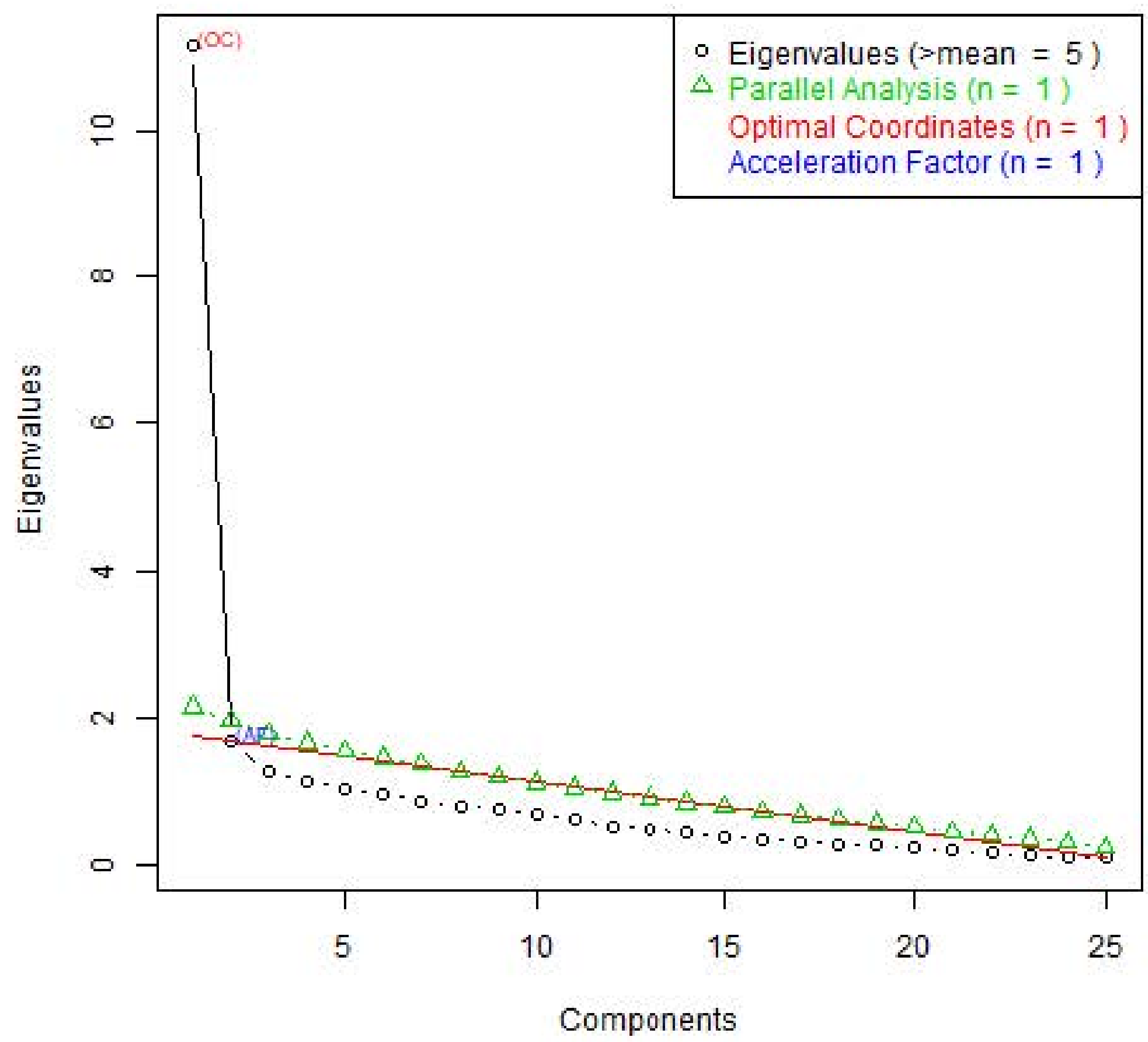

Table 1. Sample characteristics by high or low in emotional eating (EE) scale

Variable names	Total		High EE		Low EE	
Total EE	14.87	(15.44)	26.29	(14.38)	3.47	(3.07)
Gender (male)	50	(33.33)	20	(26.00)	30	(40.00)
Hispanic *	47	(32.00)	17	(24.30)	30	(40.00)
BMI z-score	2.00	(0.34)	1.99	(0.35)	2.01	(0.33)
Loss of control eating (%) *	43	(29.30)	29	(40.80)	13	(17.60)
CBCL						
Internalizing percentile	42.54	(29.19)	44.36	(28.08)	40.98	(30.57)
Externalizing percentile	34.80	(27.53)	38.18	(27.97)	31.03	(26.68)
Total percentile	40.68	(28.64)	43.06	(28.01)	37.94	(29.17)

Mean (SD) or N (%) were reported; t-statistics were used; * <0.05; EE- emotional eating; CBCL – child behavioral check list

Table 2. Correlation coefficient between percentile of internalizing, externalizing, and total behavior problems and sum of total EES-C and extracted factor structures

	Internalizing	Externalizing	Total
EES-C Total	-.03	.02	.00
EES-C TFS-F1	-.03	.02	.02
EES-C TFS-F2	-.05	.03	-.02
EES-C TFS-F3	-.08	-.06	-.08
EES-C FFS-F1	-.04	.05	-.01
EES-C FFS-F2	-.06	.04	.01
EES-C FFS-F3	-.02	.04	.04
EES-C FFS-F4	-.08	-.06	-.08
EES-C FFS-F5	-.01	.06	.06

No factor structures were significant at the .05 level

Table 3. Standardized bi-factor loadings and indices from three-factor solution (TFS)

		GF	TFS-F1	TFS-F2	TFS-F3
1	Resentful	0.70			
2	Discouraged	0.66	0.31		
3	Shaky	0.74		0.24	
4	Worn out	0.57			
5	Not doing enough	0.70	0.24		
6	Excited	0.72		0.35	
7	Disobedient	0.75			
8	Down	0.64	0.36		
9	Stressed out	0.70			
10	Sad	0.66	0.30		
11	Uneasy	0.73		0.28	
12	Irritated	0.74		0.28	
13	Jealous	0.71			
14	Worried	0.65	0.36		
15	Frustrated	0.77			
16	Lonely	0.61	0.34		
17	Furious	0.64			0.79
18	On edge	0.76	0.23		
19	Confused	0.71	0.25		
20	Nervous	0.67		0.21	
21	Angry	0.79			0.28
22	Guilty	0.58	0.42		
23	Bored	0.62		0.20	
24	Helpless	0.73	0.25		
25	Upset	0.72	0.38		
Indices					
Eigenvalue		11.98	1.31	0.61	1.01
Coefficient α		0.96			
Coefficient ω total		0.97	0.94	0.91	0.89
ω hierarchical and subscale		0.88	0.16	0.11	0.33
Reliable variance from ω		90.82	17.55	11.75	37.30
Explained common variance		0.80			
Percent uncontaminated corr		0.58			
Scalability (H)		0.94	0.55	0.31	0.63

GF= general factor; TFS-F1: Depression; TFS-F2: Anxiety; TFS-F3: Angry

Table 4. Standardized bifactor loadings and indices from five-factor solution (FFS)

		GF	FFS-F1	FFS-F2	FFS-F3	FFS-F4	FFS-F5
1	Resentful	.69	.20				
2	Discouraged	.67					.22
3	Shaky	.73	.27				
4	Worn out	.59		.24			
5	Not doing enough	.70					.23
6	Excited	.71	.37				
7	Disobedient	.76					
8	Down	.64			.44		
9	Stressed out	.70			.40		
10	Sad	.67			.31		
11	Uneasy	.71	.32				
12	Irritated	.75	.28				
13	Jealous	.70					
14	Worried	.69		.32			
15	Frustrated	.77			.25		
16	Lonely	.61					.48
17	Furious	.62				.81	
18	On edge	.78		.25			
19	Confused	.73		.26			
20	Nervous	.67	.22				
21	Angry	.80				.25	
22	Guilty	.62		.46			
23	Bored	.61	.22				
24	Helpless	.73					.32
25	Upset	.74			.37		
Indices							
Eigenvalue		12.17	.70	.68	.76	1.05	.74
Coefficient α		.96					
Coefficient ω total		.97	.92	.87	.91	1.04	.84
ω hierarchical and subscale		.92	.11	.14	.18	.33	.14
Reliable variance from ω		95.25	12.10	16.66	19.78	31.82	17.50
Explained common variance		.80					
Percent uncontaminated corr		.79					
Scalability (H)		.95	.36	.36	.43	.66	.34

GF= general factor; FFS-F1: Anxiety; FFS-F2: Guilty; FFS-F3: Down; FFS-F4: Angry; FFS-F5: Loneliness